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Art. XV.—*Description of an Arabic Quadrant. By* William H. Morley, Esq., *Librarian, Royal Asiatic Society.*

[*Read 4th February,* 1859.]

Considerable attention has been attracted of late years to the astronomical instruments of the people of Asia. Many of these instruments, though far from modern, are remarkable for accuracy and beauty of workmanship, and not a few present admirable specimens of delicate engraving, inlaying, and ornament. The Sédillots, father and son, and others, have done much to elucidate the subject; but it is still far from exhausted, and every addition to our present materials for its illustration cannot fail to be of interest.

The quadrant which I have undertaken to describe was purchased for me at Damascus a few years since, by my friend Dr. Sprenger. It offers some peculiarities not hitherto noticed, so far as I know, by other writers: it is a good example of workmanship, and is of respectable antiquity, having been constructed in A.H. 735 (A.D. 1334). The fac-similes of the inscriptions on the quadrant which I have added, have been printed in lithographic ink from the instrument itself, and transferred to the stone by double transfer, so that they present an exact reproduction of the original. I have annexed to the fac-similes, diagrams explanatory of each.

The instrument is made of brass, inlaid with gold, silver, and copper, and is in perfect preservation. The suspensory apparatus, which is like that of an Astrolabe,[1] is complete: *A* (diagram, fig. 1) is the 'Ilákah علاقة "cord," from which the quadrant hangs when in use; *B* is the Halkah حلقة "ring," to which the 'Ilákah is attached; *C* the 'Urwah عروة "handle," sometimes called the

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[1] See Description of a Planispheric Astrolabe, constructed for Sháh Husain Safawí, King of Persia, and now preserved in the British Museum; comprising an Account of the Astrolabe generally, with Notes illustrative and explanatory: to which are added, Concise Notices of Twelve other Astrolabes, Eastern and European, hitherto undescribed. By William H. Morley. Grand-eagle folio, with 21 Plates. London, 1856. As my work on the Astrolabe is somewhat costly, and a very limited number of copies were printed, I shall transfer into the present paper such portions of it as are necessary for the description of my quadrant, without giving further references to the original work.

Habs حبس "prison," receives the Halkah, and its flattened extremities are fastened by means of a rivet to the quadrant itself, securing to the latter the utmost freedom of motion, but without shake, between the extremities of the 'Urwah. I shall now proceed to describe the inscriptions on the two faces of the instrument.

Those on the first face (fig. 1) differ from any that I have seen in other quadrants, and are nearly identical, though only partially traced, with those usually found upon the face of astrolabes that are constructed to be used at one place or station only, and in which the Umm ام "mother," and the Hajrah حجرة "side," are in one plane. *D d*, *E e*, are portions of the Hajrah, sometimes called the Kiffah كفة "rim," or the Tauk طوق "ring," "collar;" the Hajrah is the limb of the astrolabe, and is divided into 360 degrees. The arc *D H* is the Kaus al-Irtifá' قوس الارتفاع "arc of altitude:" it is a quadrant of the Hajrah, and is divided into 90 degrees, arranged and numbered both ways, five and five; each degree is divided into two portions, each of course comprising 30 minutes. The continuation of the Hajrah, *H d*, is similarly divided and numbered by fives, both ways, from 0° to 25°, and from 65° to 90°. *E e*, the completion of the half of the Hajrah of an astrolabe, is placed against the Tropic of Cancer, and is numbered by fives, both ways, from 0° to 65°, and from 15° to 80°.[1]

Next within the arc of altitude and its divisions, which form the first band, is the arc of the shadow, measured by fingers, forming, with its divisions, a band *F f:* it is divided into 90 degrees, arranged and numbered by threes up to 45°, then by fives to 70°, and finally by tens to 90°; at *F* are the words Zill Asábi' ظل اصابع "shadow of fingers."

Inside the arc of the shadow, there is a stereographic projection of the sphere partially traced. It is similar to that found on the Safáïh صفائح "tablets:" the ordinary tablets of astrolabes. First are the two diameters. The line *D P e* is the Khatt[2] Wasat as-Samá

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[1] It appears to me that these last-mentioned numbers are understated each time by ten; they should be from 25° to 90°.

[2] The word Khatt خط "line," when used in describing the sphere, signifies the intersection of the plane of any great circle with that of the horizon, or any circle parallel therewith. For example: 'Abd al-'Alí Barjandí, in his Commentary on the Prolegomena to Ulugh Bég's Tables, defines the Khatt Nisf an-Nahár, or meridian line, as the section common to the plane of the circle of the meridian and that of the horizon, either rational or sensible.

خطّ وسط السماء "line of the midst of heaven,"[1] also called the Khatt Nisf an-Nahár خطّ نصف النّهار "line of midday:" this latter appellation is, however, more strictly employed to signify the portion of the line, *D h*, above the horizon; the lower portion, *h c*, being termed the Khatt Nisf al-Lail خطّ نصف اللیل "line of midnight," or the Khatt Watad al-Arz خطّ وتد الارض "line of the pivot of the earth," or the Khatt az-Zawál خطّ الزوال "line of the going down (of the sun)." The line *H G* at right angles to *D P c*, is a portion of the horizontal diameter, called the Khatt al-Istiwá خطّ الاستواء "straight," or "level line," or the Ufk al-Istiwá افق الاستواء "right," or "straight horizon." This straight horizon is also named the Khatt al-I'tidál خطّ الاعتدال "line of equality," *i.e.*, "the line of the equinoxes," and very frequently the Khatt Wasat al-Mashrik wa al-Maghrib خطّ وسط المشرق و المغرب "line of the midst of the East and the West;" the line *H G*, if produced to *P*, would be termed the Khatt al-Mashrik خطّ المشرق "line of the East;" the remaining half, not shown on the quadrant, being the Khatt al-Maghrib خطّ المغرب "line of the West." Of these two diameters, the perpendicular represents the solstitial colure and the meridian; the horizontal, the colure of the equinoxes, and the *line* of

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خطّ نصف النّهار فصل مشترکست میان سطح دائرهٔ نصف النّهار و سطح افق حقیقی و فصل مشترک را میان سطح نصف النّهار و سطح افق حسّی نیز خطّ نصف النّهار کویند

It must be understood, however, that the word Khatt does not mean the *line* of intersection *as such*, but that it is merely an accidental name of a circle of the projected sphere, where the *projection of such circle* happens to be *also* the intersection of its plane with the circle of projection. The European authors used the word *line* in the same sense.

[1] The circle of the midst of the apparent heaven is defined by 'Abd al-'Alí Barjandí as a great circle passing through the poles of the ecliptic and those of the horizon:

و دائرهٔ عظیمه که بقطب افق و قطب منطقة البروج کذرد آنرا دائرهٔ اقلیم رویت و وسط سماء رویت کویند بجهت آنکه منصف نصفین منطقة البروج است

intersection of the planes of the equinoctial, and of the prime vertical with that of the horizon. The point *P*, where the line *H G*, if produced, and the line *D P e* would intersect, is the North Pole. We now come to the three circles, of two of which a quadrant only is traced, and of the third, a semicircle. *I K*, forming the inner portion of the arc of the shadow, is a fourth part of the Tropic of Capricorn, or the Madár rás al-Jadí مدار راس الجدي "circle of the head of Capricorn," sometimes called Al-Munkalab ash-Shatawí المنقلب الشّتوي. *L G* is a quadrant of the equinoctial, or the Madár Awwal al-Hamal wa-Awwal al-Mízán مدار اوّل الحمل واوّل الميزان "circle of the beginning of Aries and the beginning of Libra," otherwise termed the Madár Rás al-Hamal مدار راس الحمل "circle of the head of Aries," the Mu'addal al-Lail wa an-Nihár معدّل الليل و النّهار "place of equalization of night and day," or simply the Mu'addal an-Nihár, and the Dáïrah al-I'tidál دائرة الاعتدال "circle of equality." The semicircle *M m* is the half of the third circle, viz., the Tropic of Cancer, or the Madár Rás as-Saratán مدار راس السّرطان "circle of the head of Cancer," sometimes called Al-Munkalab as-Saifí المنقلب الصّيفي "the summer place of turning." Next are the Mukantarát مقنطرات "bridges," *N n n n*, which are the almucantars, or circles parallel with the horizon. The first almucantar, *N h*, which passes through the points where the equinoctial cuts the straight horizon, is called the Ufk افق "horizon," or the Ufk al-Mashrik wa al-Maghrib افق المشرق و المغرب "horizon of the East and the West." The Ufk is the true or astronomical horizon, which separates the upper from the lower hemisphere, so that all that is above it is visible at the place for which the projection was constructed, and all below it hidden. The portion that is above it, both in reality and in the projection, is called Fauk al-Arz فوق الارض "above the earth;" that which is under is termed Taht al-Arz تحت الارض "below the earth." The arc *N G h* is the portion of the Ufk called the Ufk al-Mashrik افق المشرق "horizon of the East;" the point *G* is termed the Nuktah al-Mashrik نقطة المشرق "East point;" the corresponding portion and point on the west side of the meridian line, not shown on this instrument, are called the West horizon and West point. The two points are sometimes called the Mashrik al-I'tidál مشرق الاعتدال "East of the equinoctial," and Maghrib al-I'tidál,

مغرب الاعتدال "West of the equinoctial," that is, the equinoctial points. The centre of the almucantars, *Z*, within the arc *N G h*, is the zenith, and is called the Samt ar-Rás سمت الرّاس "direction of the head," or the Kutb al-Ufk كتب الافق "pole of the horizon." From the Ufk to the Samt ar-Rás the division is into 90 degrees. Astrolabes are classed by the number of almucantars which are traced: where there are ninety circles, comprising the Ufk, the instrument is called Támm تام "perfect," "complete," or "solipartite;" where there are forty-five circles, it is termed Nisfí نصفي "bipartite;" the Thulthí ثلثي "tripartite," contains thirty circles; and so on until the decempartite. The almucantars on our quadrant, *N n n n*, are of the third description, or tripartite, there being a separate circle for every three degrees, numbered three and three from 3 to 36 within the Tropic of Capricorn, from *N* to *I*; and then from 36 to 90 on the outside of the meridian line, from *I* to *Z*; thence from *Z* to *h* they are numbered, still outside the meridian line, six and six, from 90 to 6. The almucantars *n n n*, within the Ufk, are termed the Mukantarát al-Irtifá' مقنطرات الارتفاع "almucantars of altitude," and these are the only ones usually found in astrolabes. But there are other almucantars occasionally but very rarely inscribed, which are placed below the horizon, and are called the Mukantarát al-Inhitát مقنطرات الانحطاط "almucantars of declination." These, *O o o o*, are traced in the present instrument, within the Tropic of Cancer, three and three, beginning from the Ufk, or true horizon; the numbering, outside the meridian line, is by sixes, from 6 to 30; the last number is 33, which brings the almucantars of declination almost to that which is equal to the latitude of the place for which the projection was constructed, which would be a straight line parallel with the straight horizon. Outside the Ufk, at its eastern extremity, between *N* and *G*, the latitude is written, viz., "For the latitude 33° 27′." This latitude is that of Damascus, for which place the instrument was constructed.[1] The Sumút سموت "ways," "directions," *G g g g* next claim our attention; they are the azimuths, or vertical circles, and are traced ten and ten, above the earth within the horizon, and below the earth as well, within the Tropic of Cancer. The arc *G Z* is called the Awwal as-Sumút اوّل السموت "first of the azimuths," or the Dáirah al-

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[1] Eastern geographers vary very much in their statements of the latitude of Damascus, but the latitude as given on the quadrant is correct.

Mashrik wa al-Maghrib دائرة المشرق و المغرب "circle of the East and the West;" it is the primo vertical. The azimuths are not numbered. The arc *G I* is the portion of the zodiac above the straight horizon, when the head of Capricorn is in apposition with the southern extremity of the meridian line; the arc *G M* is the remainder of the zodiac when in a reversed position. In both these arcs each sign is divided into thirty degrees, marked by threes; the signs are not indicated by writing as is usual on the 'Ankabút or Rete of an astrolabe. The arc *Q q*, distinguished by being dotted, is the Khatt al-'Asr خط العصر "line of the afternoon," or time of afternoon prayer.

This completes the description of the lines and circles on this face of the instrument; but in addition to these there are set down various fixed stars, with their names and right ascensions, as follows:— *I.* Rijl al-Jauzá رجل الجوزا for Rijl al-Jauzá al-Yusra رجل الجوزا ليسرى "the left foot of Jauzá," 160° 38′ (β Orionis; Rigel; Rigel Algeuze). *II.* Jabhah al-'Akrab جبهة لعقرب "the forehead of the Scorpion," 321° 47′ (β and ω Scorpii). *III.* Matn متن for Matn al-Faras متن الفرس "the back of the horse," 67° 47′ (α Pegasi; Markab). *IV.* Al-Fard الفرد "the solitary one," 228° 48′ (α Hydræ; Alferd; Cor Hydræ). *V.* Jasad Kítas جسد قيطس "the body of the Whale," 109° 7′ (ζ Ceti; Batan Kaitoz). *VI.* Ad-Dulfín الدلفين "the Dolphin," 30° 37′ (β Delphini). *VII.* Bula' بلع "the Glutton," 32° 28′ (ε Aquarii. μ, ν, ε, Aquarii form the 23rd Lunar Mansion). *VIII.* At-Táïr الطّائر "the Bird," 18° 40′ (α Aquilæ). *IX.* Shamálí az-Zábih شمالى الذّابح "the Northern (star) of the Sacrificer," 25° 26′ (α Capricorni. α and β Capricorni form the 22nd Lunar Mansion). *X.* Suhail سهيل "the star Canopus," 181 58′ (α Navis). *XI.* Fam Hút فم حوت for Fam al-Hút فم الحوت "the mouth of the Fish," 305° 59′ (α Piscis Australis; Fomalhaut). *XII.* Yamániyah يمانيّة for Ash-Shi'ra al-Yamániyah الشعرى اليمانيّة "the Dog Star of Yaman," 184° 10′ (α Canis Majoris; Sirius).

The small projecting plates *R R* are the pinnules; they are parallel one to the other, and their height slightly exceeds their width; they are called the Libnatán لبنتان "the two tiles," and sometimes the Daffatán دفّتان "the two boards of a book," or the Hadafán هدفان "the two archers' butts." Through each of these pinnules is bored a small aperture or Thukbah ثقبة "hole," for observing the celestial bodies: the two holes together are called the Thukbatán al-Irtifá' ثقبتان الارتفاع "the two holes of altitude," the line joining the centres of the two apertures is parallel to the plane of the instrument. Lastly, *S* is the Murí مرى "index," or the plumb line.

The following inscription is inlaid in silver at *T*,—

مّما عمل برسم الشّيخ شمش الدّين بن سعيد رئيس
المؤذّنين بالجامع الاموّى سنة ذله
صنعه على بن الشّهاب

"Constructed for the use of the Shaikh Shams ad-Dín Ben Sa'íd, the Chief of the Muazzins in the Jámi' al-Úmawí (the mosque of the descendants of Umayyah[1]), in the year 735 (A.D. 1334), by 'Alí Ben ash-Shiháb."

At *U* there are the words:—

نقش محمّد بن الغزولى

"Engraved by Muhammad Ben al-Ghazúlí."

There are some words scratched in the space between *D* and the lower Libnah *R*, which have been so effaced as to be illegible. They evidently did not form any part of the original inscriptions, and are quite unimportant.

The second face of the instrument, with its inscriptions, presents the series of sines found in the species of quadrant called the Rub' ad-Dastúr ربع الدستور "Quadrant of the canon." *C* is the Urwah with its appendages. The arc *b f* is the arc of altitude, and is divided into 90 degrees, numbered both ways by fives, each degree being further divided into two parts. The horizontal boundary line, or radius *c f*, is the whole sine; the perpendicular radius *c b* is the cosine. Each of these extreme radii is divided into 60 equal parts, numbered by fives both ways, each part being divided again into two, thus forming 120 divisions of each radius. From each radius 60 parallels or sines are drawn to the arc of altitude: those parallel to the whole sine being termed Mankús منكوس "inverted;" those parallel to the cosine Mabsút مبسوط "extended." Every fifth sine in the present instrument is inlaid with copper. In large instruments the sines are drawn from each degree of the arc of altitude both ways, *i.e.*, perpendicular to each extreme radius of the quadrant, the sines both Mankús and Mabsút being of course 90 in number, and dividing either radius into 90 unequal parts, in which case the quadrant is termed nonagesimal; but in small instruments this is impracticable, since towards the extremities of the arc the divisions would become so minute as to be undistinguishable. Quadrants, where the sines are drawn from the radii to the arc, as in the present instance, are called sexagesimal. The three arcs, *c f*, *d d*, and *e e*, (the first two of which are inlaid with silver, and the last with gold,) appear to be inscribed as a convenient method of reading sines; the arc *c f* to a radius of 60°, and to a diameter of 60°; the arc *d d* to a radius of 24°; and the arc *e e* to a radius of 40°.[1]

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[1] This mosque is sometimes called the Jámi' Baní Umayyah, and is the most remarkable of all the mosques in Damascus, both on account of its vast size and its architecture. Some authors say that it was built by the Emperor Heraclius; by others it has been considered to have been the work of the bishops of that See. It appears to be generally acknowledged that it was formerly the church of St. John of Damascus. It was entirely rebuilt by the Khalífah Walíd Ben 'Abd al-Malik in A.H. 96 (A.D. 714), and has since then borne the name of the mosque of the descendants of Umayyah. In the centre of the mosque there is a tomb containing the head of the martyr St. John, son of Zacharíah; a relic equally venerated by Christians and Muhammadans. In the account of Damascus translated from the Kitáb Manásik al-Hajj by M. Bianchi, and inserted by him in the second volume of the Memoirs of the Geographical Society of Paris, p. 113, *et seq.*, there is a most interesting description and history of the Jámi' al-Umawí. The author of the Kitáb Manásik al-Hajj states, that when he wrote, in A.H. 1093 (A.D. 1682), there were no less than seventy-five Muazzins attached to this mosque.

In the space marked *C* is the word Al-Jaib الجيب "sine," inlaid with silver. At *A* is the word al-A'zam الاعظم "greatest," and at *B* the word Kullí كلي "total," also inlaid with silver. The word al-Jaib requires no explanation, the other two have reference to the obliquity of the ecliptic. The terms al-Mail al-A'zam الميل الاعظم "greatest obliquity," or al-Mail al-Kullí الميل الكلي "total obliquity," signify the greatest distance between the equinoctial and the ecliptic, measured upon the solstitial colure.[2]

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[1] See, however, M. L. A. Sédillot's remarks in the Mémoires présentés par divers savants à l'Académie Royale des Inscriptions, 1re Série, Tome I., pp. 68, 72, 84, 90. It seems possible, from what is there written and quoted, that the arc *c f* is that of the sixth unequal hour; *d d* that of the obliquity of the ecliptic; and *e e* that of the 'Asr.

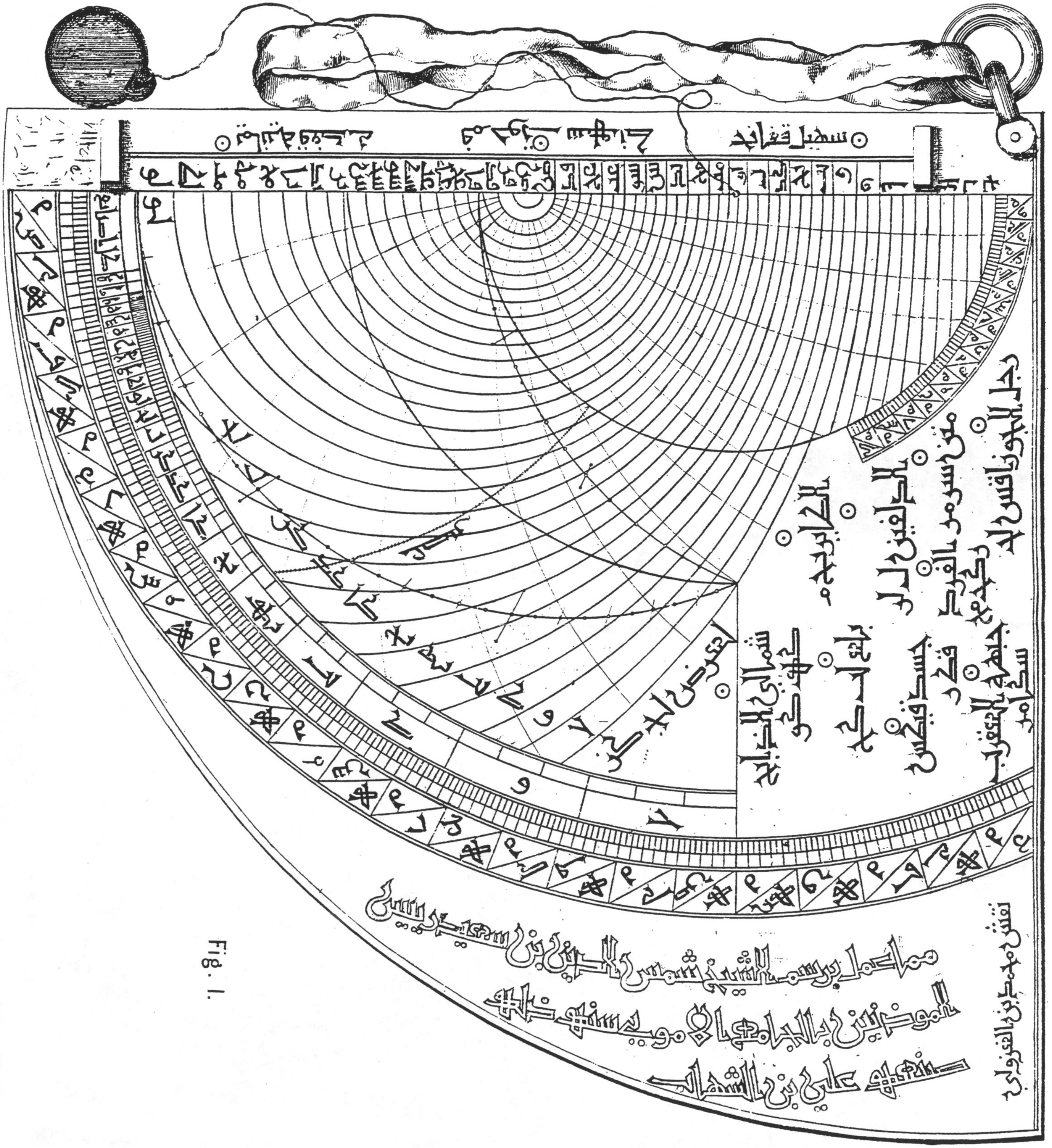
[2] These terms appear to have been used, not only because they indicate the sun's greatest declination, or obliquity of the ecliptic, but also in distinction from the Mail al-Awwal ميل الأوّل "the first obliquity," and the Mail ath-Thání

At *c*, the centre of the quadrant, there is a hole pierced, which contained a portion of thread when the instrument came into my hands, and from which no doubt depended a Murí, or plumb line, applicable to this second face of the quadrant. There is also a similar perforation at *b*, which was possibly for the introduction of a third Murí, but there are no vestiges of it remaining.

میل الثّانی "the second obliquity." 'Abd al-'Alí Barjandí, in his Commentary on the Prolegomena of Ulugh Bég, defines the Mail al-Awwal as the arc of a circle of declination, comprised between a definite portion or point of the ecliptic and the equinoctial in the nearest direction; the Mail ath-Thání as the arc of a circle of latitude, comprised between the aforesaid point and the equinoctial in the nearest direction; and the Mail al-Kullí as the arc of a circle passing through the four poles (*i.e.*, of the world, and of the zodiac—the solstitial colure) comprised between the ecliptic and the equinoctial in the nearest direction.

و قوسی از دائرهٔ میل که مابین جزٔ مفروض از منطقة البروج و
معدّل النّهار باشد از جانب اقرب آن را میل اوّل آن جزٔ کویند
وقوسی از دائرهٔ عرض مابین جزٔ مفروض مذکور و معدّل النّهار
از جانب اقرب آن را میل ثانی آن جزٔ کویند و قوسی‌را از
مارّه بافتاب اربعه مابین منطقة البروج و معدّل النّهار از جانب
اقرب میل کلّی کویند

The first and second obliquities, when referrible to the same point of the ecliptic, form the two sides of a spherical triangle, having for its base an arc of the equinoctial, and for its apex the given point of the ecliptic: both obliquities have the same maximum, viz., the total obliquity.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المؤذنين بالجامع الاموي
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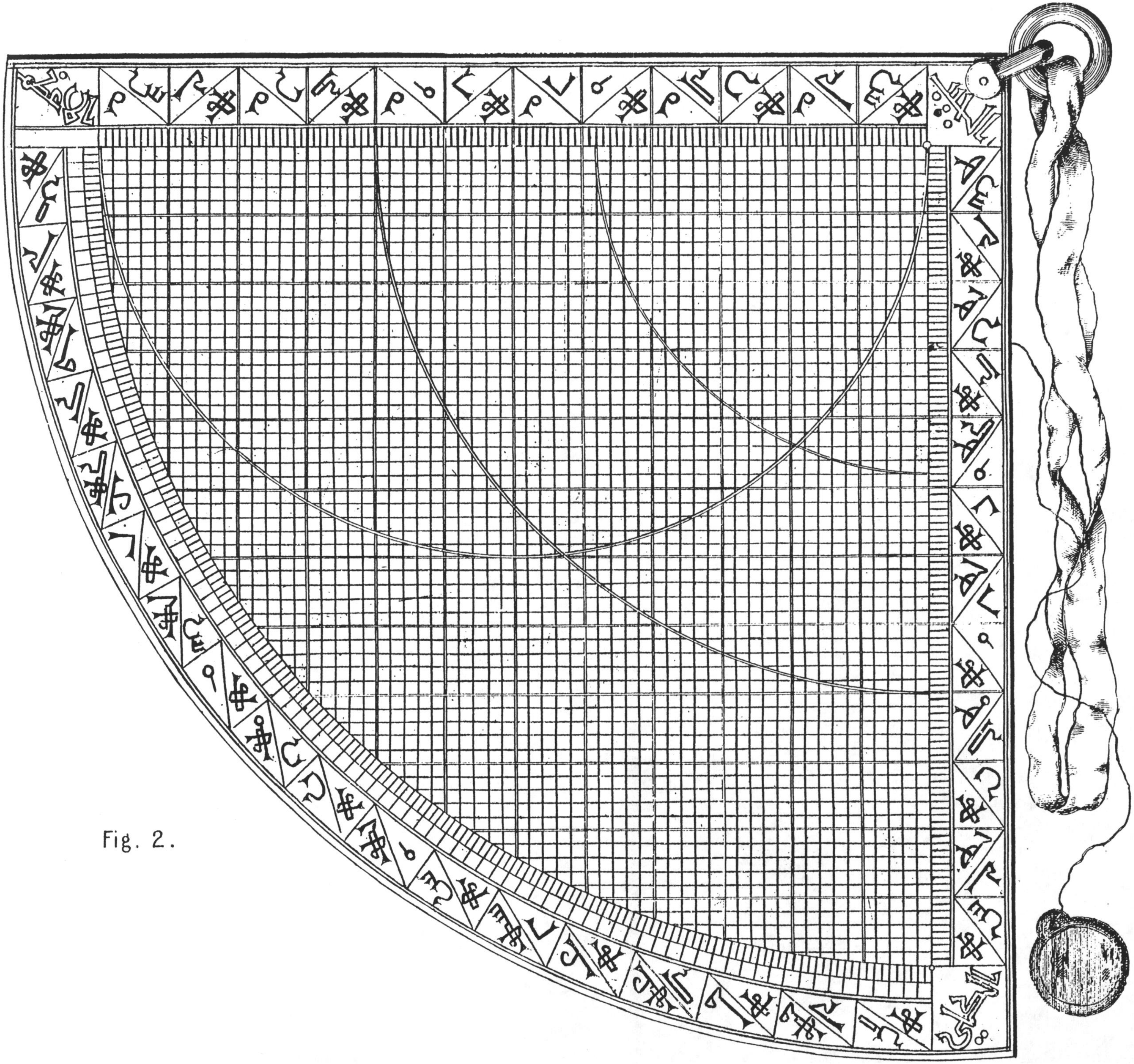
نقش محمد بن الغزولي
سهيل

Fig. 1.



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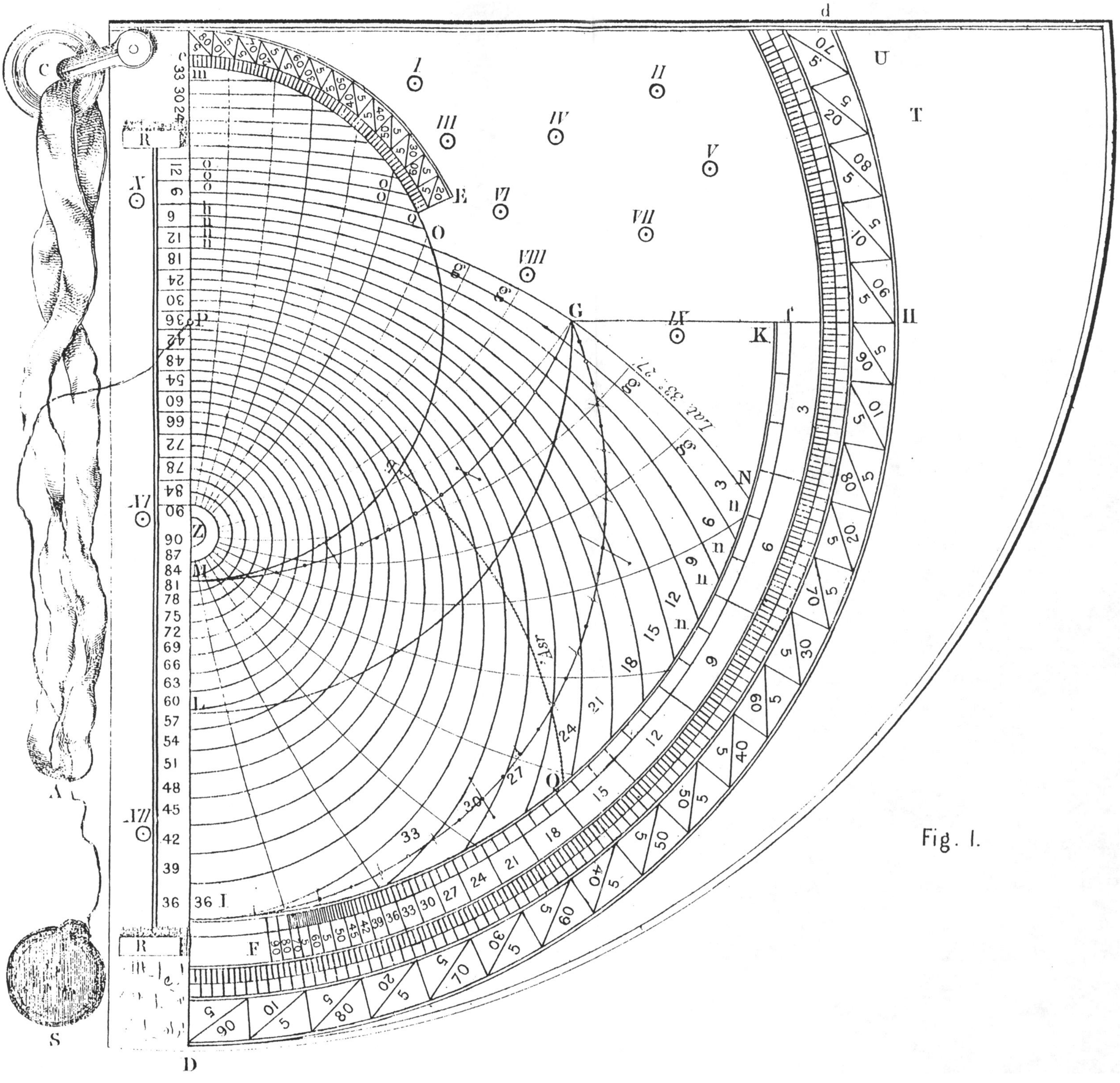
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Fig. 1.

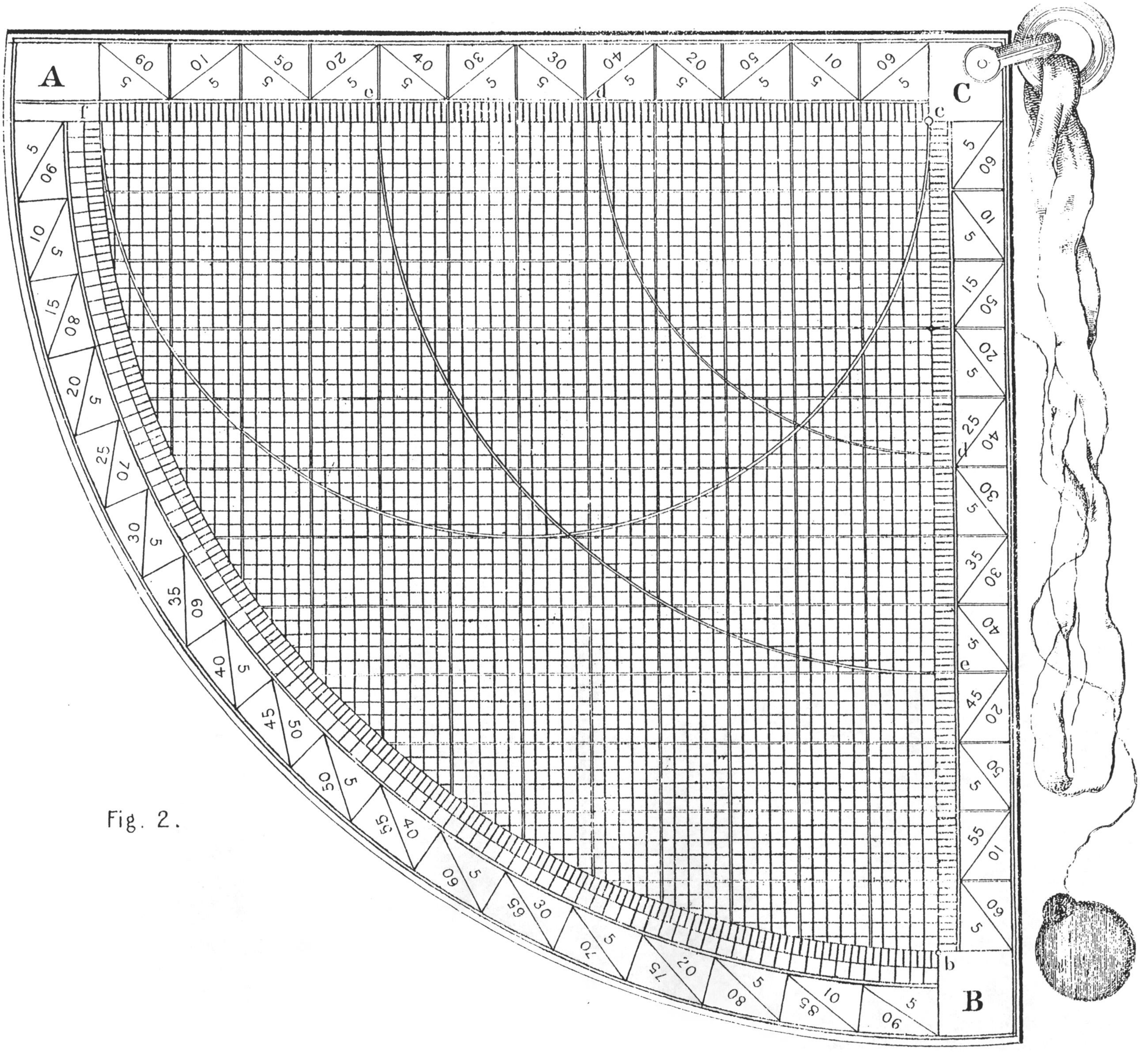

Fig. 2.